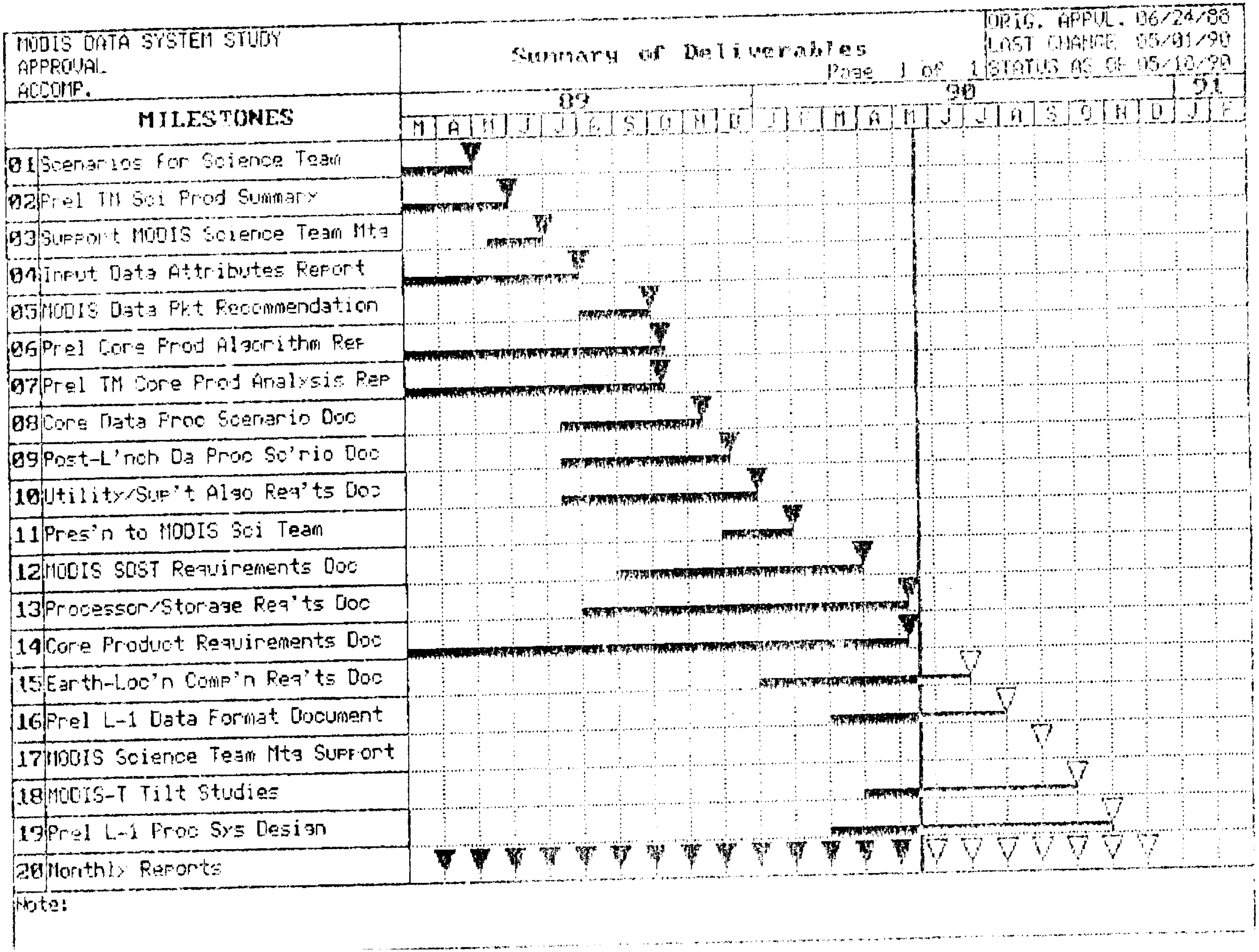
MODIS DATA STUDY
TEAM PRESENTATION

May 18, 1990

AGENDA

1. Milestone Update of Deliverables (Ardanuy)
2. Areas of Emphasis for Upcoming MODIS Deliverables (Ardanuy)
3. MODIS Data Product Requirements Document Delivered (Data Team)
4. Effects of Atmospheric Composition and Viewing Geometry on MODIS and AVHRR Normalized Difference Vegetation Indices (Hoyt)


MODIS DATA SYSTEM STUDY
APPROVAL
ACCOMP.
Summary of Deliverables
Page 1 of 1
ORIG. APPVL. 06/24/88
LAST CHANGE 05/01/90
STATUS AS OF 05/10/90
89
90
91
M A M J J A S O N D J F M A M J J A S O N D J F
MILESTONES
01 Scenarios for Science Team
02 Prel TM Sci Prod Summary
03 Support MODIS Science Team Mtg
04 Input Data Attributes Report
05 MODIS Data Pkt Recommendation
06 Prel Core Prod Algorithm Rep
07 Prel TM Core Prod Analysis Rep
08 Core Data Proc Scenario Doc
09 Post-L'nch Da Proc Sc'rio Doc
10 Utility/Sup't Algo Req'ts Doc
11 Pres'n to MODIS Sci Team
12 MODIS SDST Requirements Doc
13 Processor/Storage Req'ts Doc
14 Core Product Requirements Doc
15 Earth-Loc'n Comp'n Req'ts Doc
16 Prel L-1 Data Format Document
17 MODIS Science Team Mtg Support
18 MODIS-T Tilt Studies
19 Prel L-1 Proc Sys Design
20 Monthly Reports
Note:

AREAS OF EMPHASIS FOR UPCOMING MODIS DELIVERABLES

1. Earth Location Computation Requirements (July 1)

    - Requirements of Ocean Discipline
    - Requirements of Land Discipline
    - DEM/DTM Requirements
    - Cloud Altitude and Shadow
    - GPS Processing Requirements and Attributes
    - Trade Offs for Sphere vs. Ellipsoid vs. Geoid Model
    - Utility of GGI for MODIS Data Processing
    - Update on GE Attitude Specifications for Platform
    - Planning and Scheduling Requirements for Unusual Latitudes
    - Refraction Correction
    - Possible Use of Ground Control Points for 214 m (250 m L-3)
    - Procedures for Other Relevant EOS Instruments (i.e., HIRIS)
    - Validation of Earth Location
    - Reliability Issues for Star Trackers
    - Processing and Storage Trade Studies

2. Preliminary Level-1 Data Format Document (August 1)

    - Requirements of Ocean Discipline
    - Requirements of Land Discipline
    - Requirements of Atmospheric Discipline
    - Sequential vs. Random Access
    - Scene and Cloud ID Flags
    - Accuracies and Formats
    - QA and QC Results
    - Browse and Metadata
    - Radiometric Data; Housekeeping and Engineering Data; Calibration Data
    - Product Granularity
    - ICT Support Product
    - Command and Response History
    - Retention Requirements for Old Data
    - Common Data Standards; Media Desired by Team Members
    - Data Pedigree

3. MODIS-T Tilt Strategy Sensitivity Studies (October 1)

    - Conduct Simulation Studies
    - Work with Science Team Members to Optimize Tilt Strategy

4. Preliminary Level-1 Processing System Design (November 1)

    - Word Lengths and Impacts
    - Earth Location Algorithm
    - Calibration Algorithms
    - Ancillary and Platform Engineering Data
    - Anchor Point Strategy and Design
    - Calibration at Level-1A vs. 1B
    - QA and QC Design
    - Level-0 to 1A Decommutation
    - DEM/DTM Application Design
    - Processing Masks and Control

EFFECTS OF ATMOSPHERIC COMPOSITION AND VIEWING GEOMETRY ON MODIS AND AVHRR NORMALIZED DIFFERENCE VEGETATION INDICES

by

Douglas Hoyt
Research and Data Systems, Corp.
7855 Walker Dr., Suite 460
Greenbelt, MD 20770

OBJECTIVES OF THIS TALK

- EOS AS A PART OF "MISSION TO PLANET EARTH" IS SEEKING TO ESTABLISH LONG-TERM SELF-CONSISTENT TIME SERIES OF VARIOUS PARAMETERS TO MONITOR GLOBAL CHANGES.

- THE EARTH'S VEGETATION STATE AS EXPRESSED BY THE NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI) HAS A LONG-TERM TIME SERIES THROUGH THE AVHRR MEASUREMENTS OF NOAA.

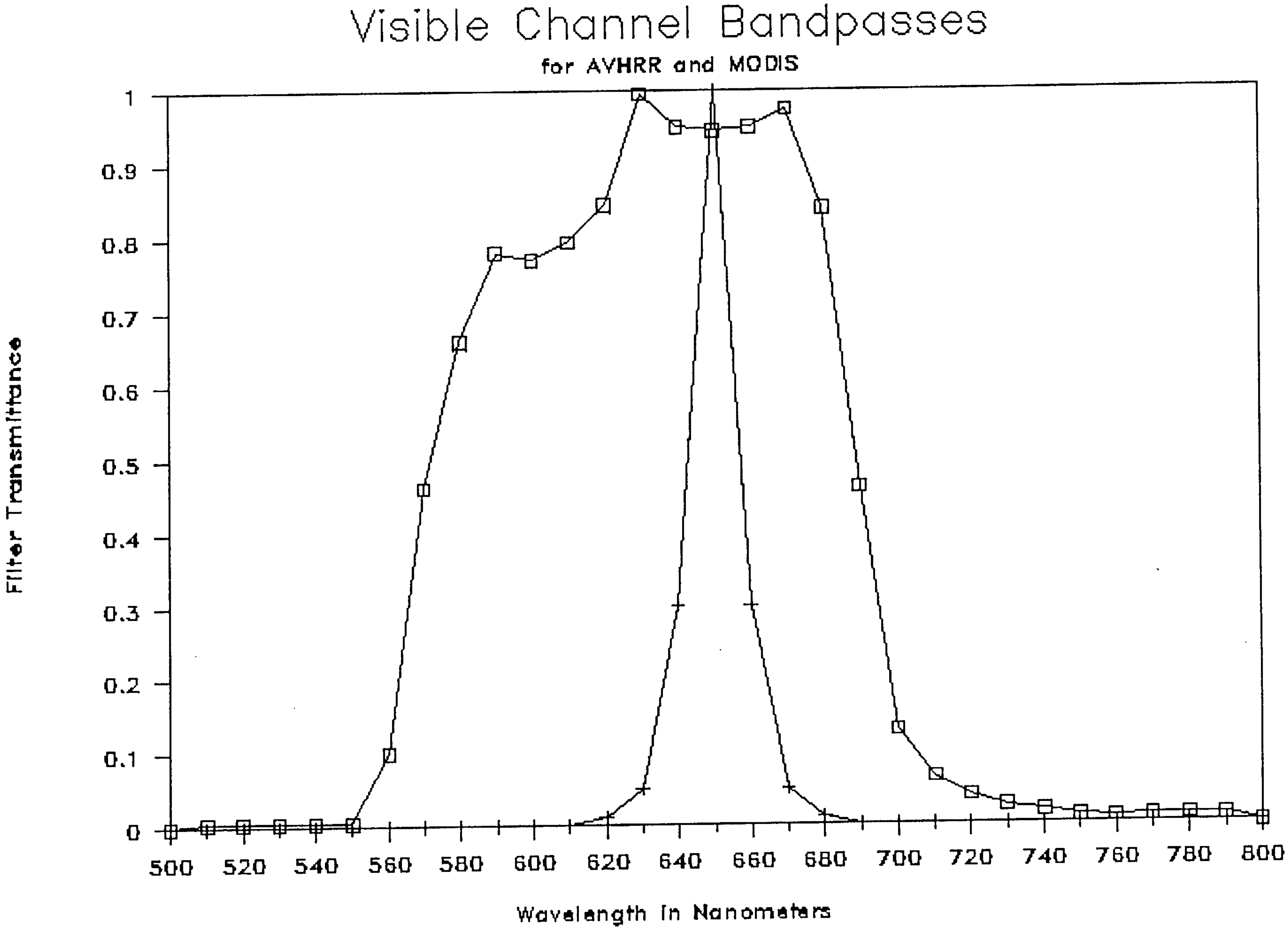
- MODIS (THE MODERATE RESOLUTION IMAGING SPECTROMETER) ON THE EOS NPOP-1 PLATFORM WILL ALSO PRODUCE AN NDVI.

- BECAUSE THE TWO INSTRUMENTS WILL MEASURE NDVI DIFFERENTLY, THERE IS THE POSSIBILITY THAT THE LONG-TERM CONTINUITY OF THE NDVI MEASUREMENTS WILL BE BROKEN.

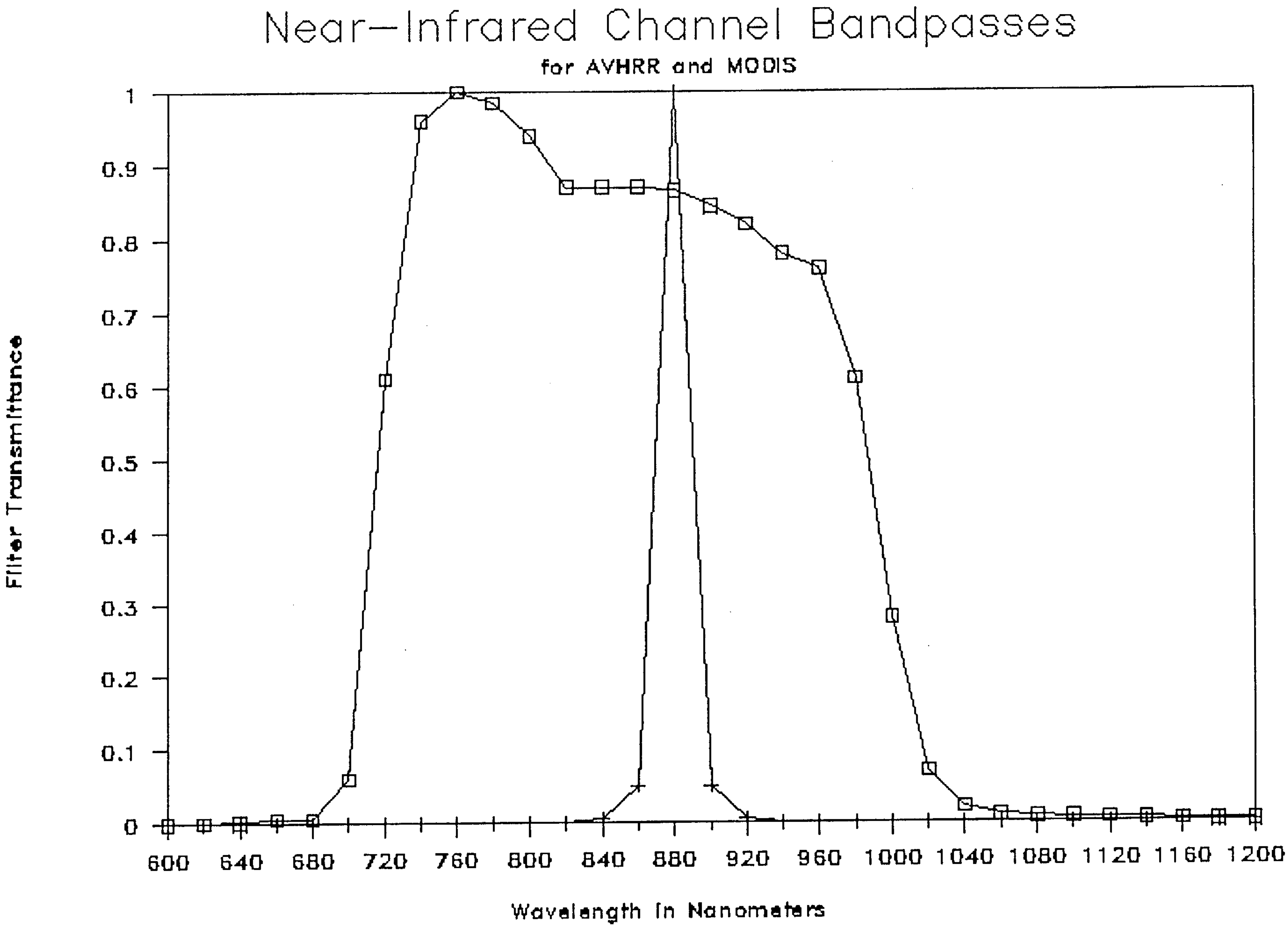
- THIS TALK EXAMINES WHAT IS INVOLVED IN MAINTAINING THE CONTINUITY OF MEASUREMENTS OF NDVI.

- SIMULATIONS OF THE AT-SATELLITE RADIANCES, AS DISCUSSED HERE, PLAY A SUPPORTING ROLE IN THE MODIS DATA STUDY TEAM'S DESIGN OF THE DATA SYSTEM. UNDERSTANDING THE PHYSICS OF THE OBSERVATIONS IS REQUIRED FOR THE INTELLIGENT DESIGN OF THE MODIS AND EOS DATA PROCESSING AND STORAGE SYSTEMS.

$$NDVI = \frac{(ch2 - ch1)}{(ch2 + ch1)}$$



Visible Channel Bandpasses
for AVHRR and MODIS
Filter Transmittance
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
500 520 540 560 580 600 620 640 660 680 700 720 740 760 780 800
Wavelength in Nanometers



Near-Infrared Channel Bandpasses
for AVHRR and MODIS
Filter Transmittance
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
600 640 680 720 760 800 840 880 920 960 1000 1040 1080 1120 1160 1200
Wavelength in Nanometers

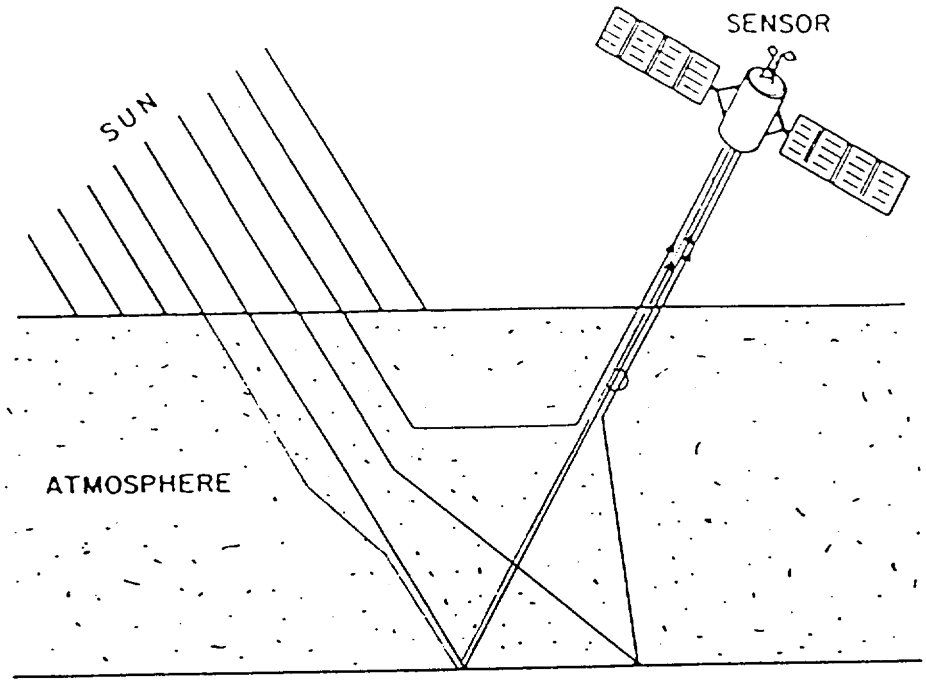


Fig. 1. Schematic diagram of the atmospheric effect on remote sensing.

Path 1 = radiation directly transmitted through atmosphere, reflected by surface, and directly transmitted to satellite.

Path 2 = radiation directly transmitted through atmosphere, reflected by surface, and diffusely transmitted to satellite.

Paths 3/4 = radiation diffusely transmitted through atmosphere, reflected by surface, and transmitted to satellite.

Path 5 = radiation which is scattered by atmosphere and never reaches the Earth's surface.

EQUATIONS FOR PATH 1 RADIANCES:

$$R_1 = D_r R_{sur} T_{ray} T_{aer} T_w T_{oz} T_u / \pi$$

where D_r = direct radiation at Earth's surface (derived from expression similar to above equation)
R_{sur} = surface albedo (wavelength dependent)
T's = various atmospheric transmission functions:

$$T_{ray} = \exp[-m(115.6406-1.335/\lambda^2)/\lambda^4)$$

$$T_{aer} = \exp[-m\beta/\lambda^{\alpha}]$$

$$T_w = \exp[-0.2385 a_w w m/(1+20.07 a_w w m)]$$

$$T_{oz} = \exp[-a_o w_{oz} m_{oz}]$$

$$T_u = \exp[-1.41 a_u m/(1+118.9 a_u m)^{0.45}]$$

where a's are absorption coefficients as function of wavelength, m's are air masses, w's are absorber amounts, beta and alpha are Angstrom turbidity coefficients, and lambda is the wavelength. The first equation is weighted by the instrument filter transmission and integrated over the band-pass. Equations for other paths are more complicated than the sample shown here.

COMPARISON OF THIS MODEL TO THE 5S MODEL OF TANRE ET AL.(1987)

Tanre et al.'s model:

1) Fortran code (8200 lines)
2) High spectral resolution(751 wavelengths in solar spectrum)
3) Handles non-uniform and non-Lambertian surfaces
4) Accurate at-satellite radiances are calculated
5) Calculations may take some time on a small computer

This model:

1) Developed on a spreadsheet for interactive response
2) Low spectral resolution (123 wavelengths in solar spectrum)
3) Lambertian surface assumed
4) Fast response on small computer
5) Atmospheric reflectance is uncertain

A comparison of the three models at 0.57 microns
with the 1962 U.S. Standard Atmosphere:
(units = mw/sq cm./sr/micron)

	Hoyt m'=1.8	Hoyt m'=2.1	Tanre	Differences compared to Tanre	
Path 1:	2.19	2.19	2.23	-1.8%	-1.8%
Path 2:	0.55	0.55	0.58	-5.2%	-5.2%
Path 3/4:	1.29	1.41	1.50	-14.0%	-6.0%
Path 5:	4.32	3.84	3.69	+17.1%	+4.1%
Total:	8.35	8.00	8.00	+4.4%	0.0%

Path 1 = radiation directly transmitted through atmosphere, reflected by surface, and directly transmitted to satellite.

Path 2 = radiation directly transmitted through atmosphere, reflected by surface, and diffusely transmitted to satellite.

Paths 3/4 = radiation diffusely transmitted through atmosphere, reflected by surface, and transmitted to satellite.

Path 5 = radiation which is scattered by atmosphere and never reaches the Earth's surface.

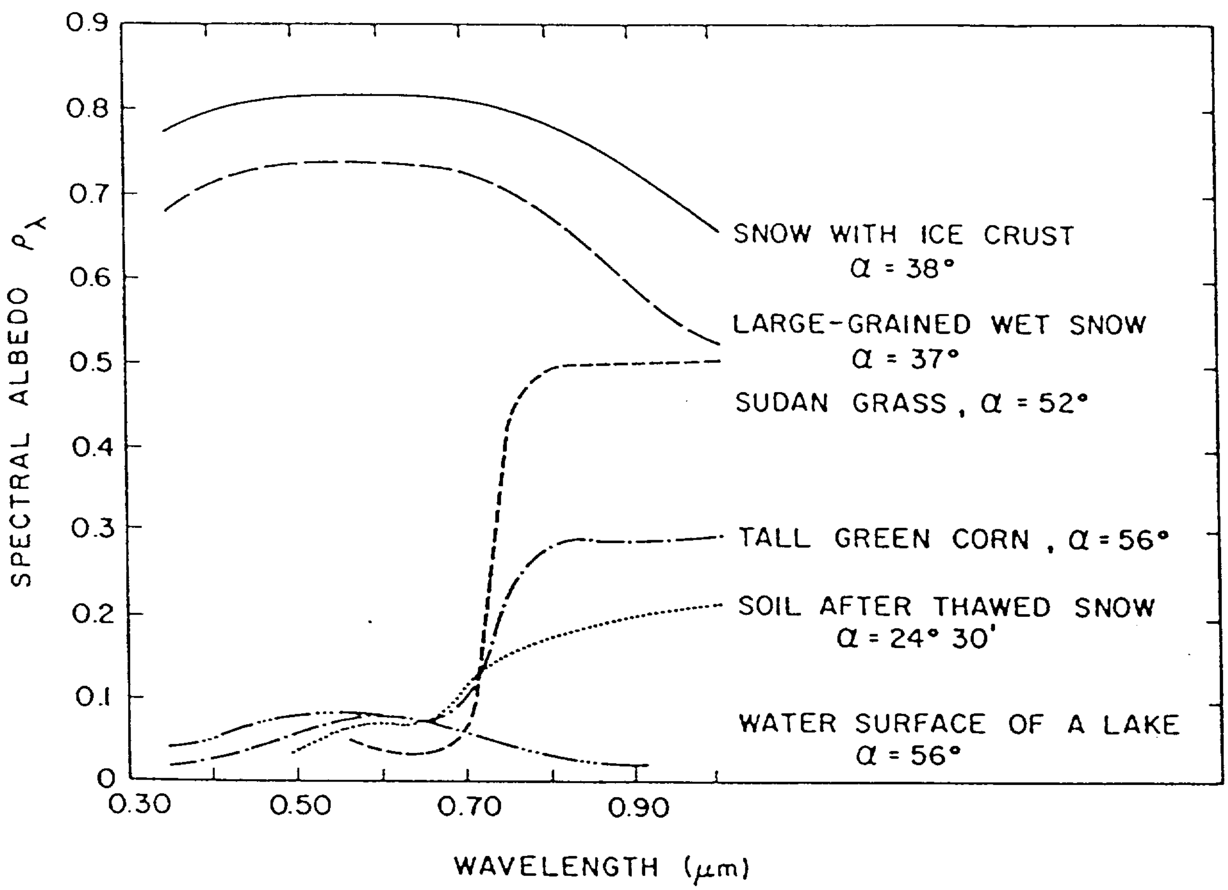
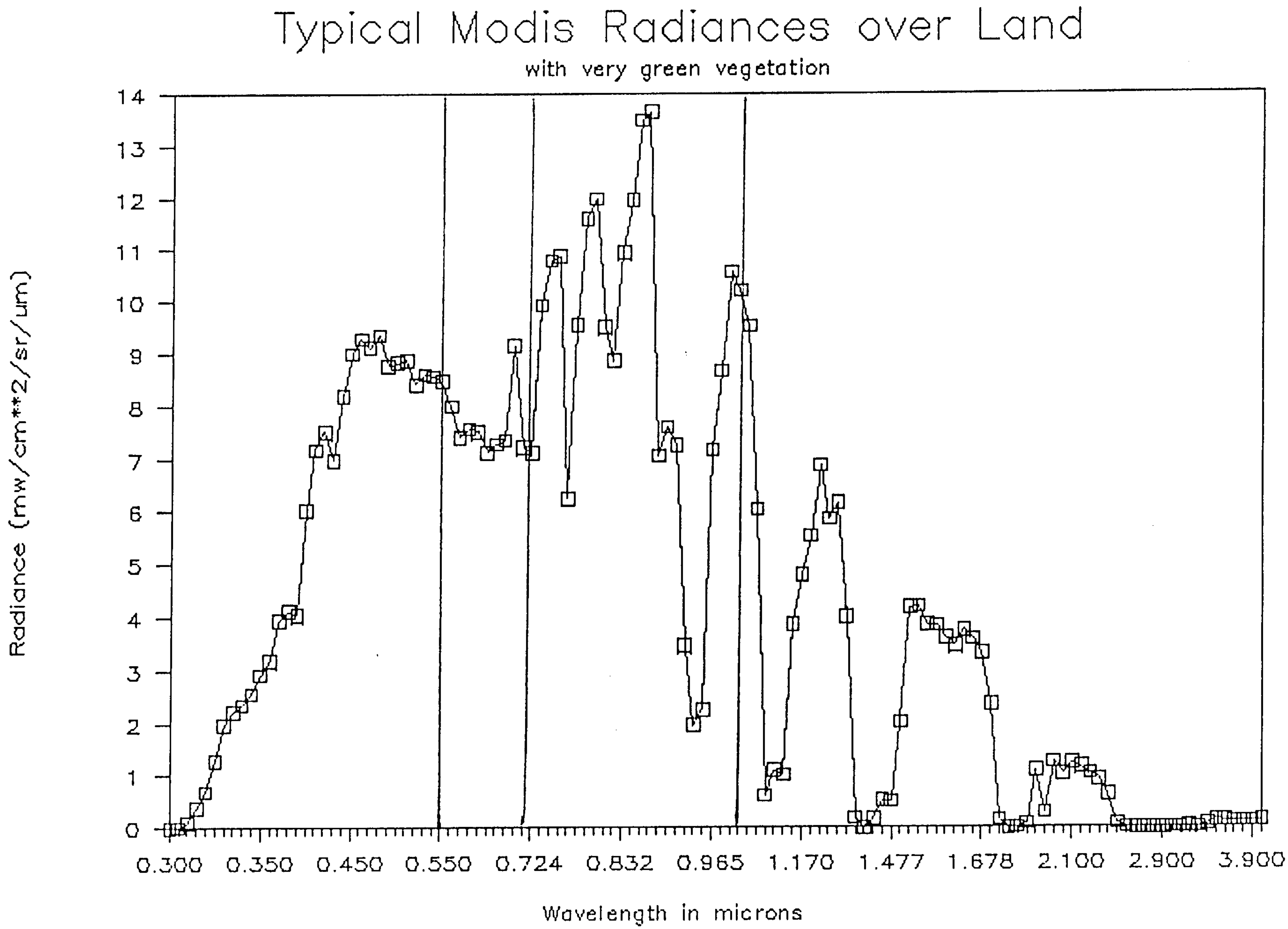
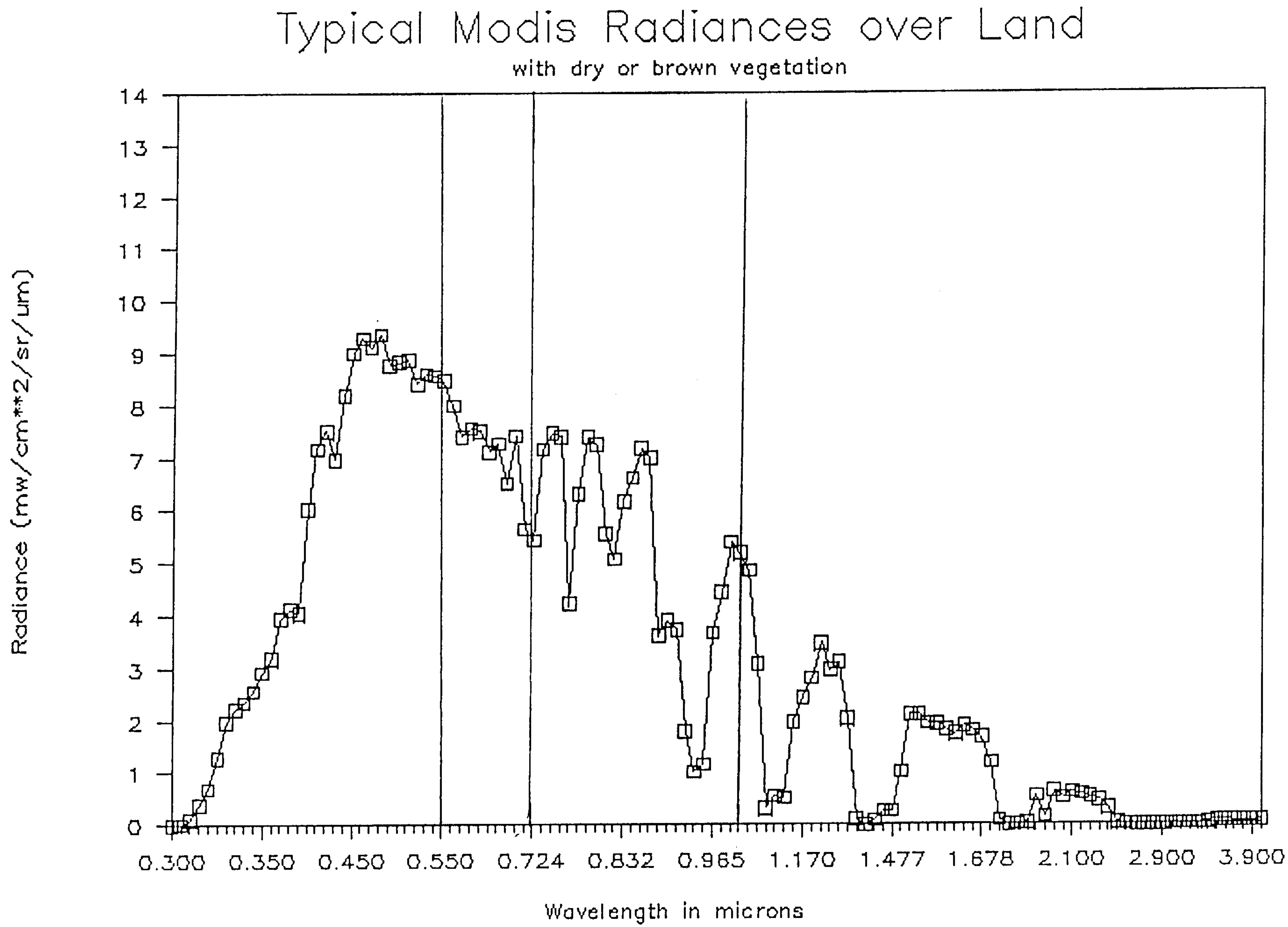
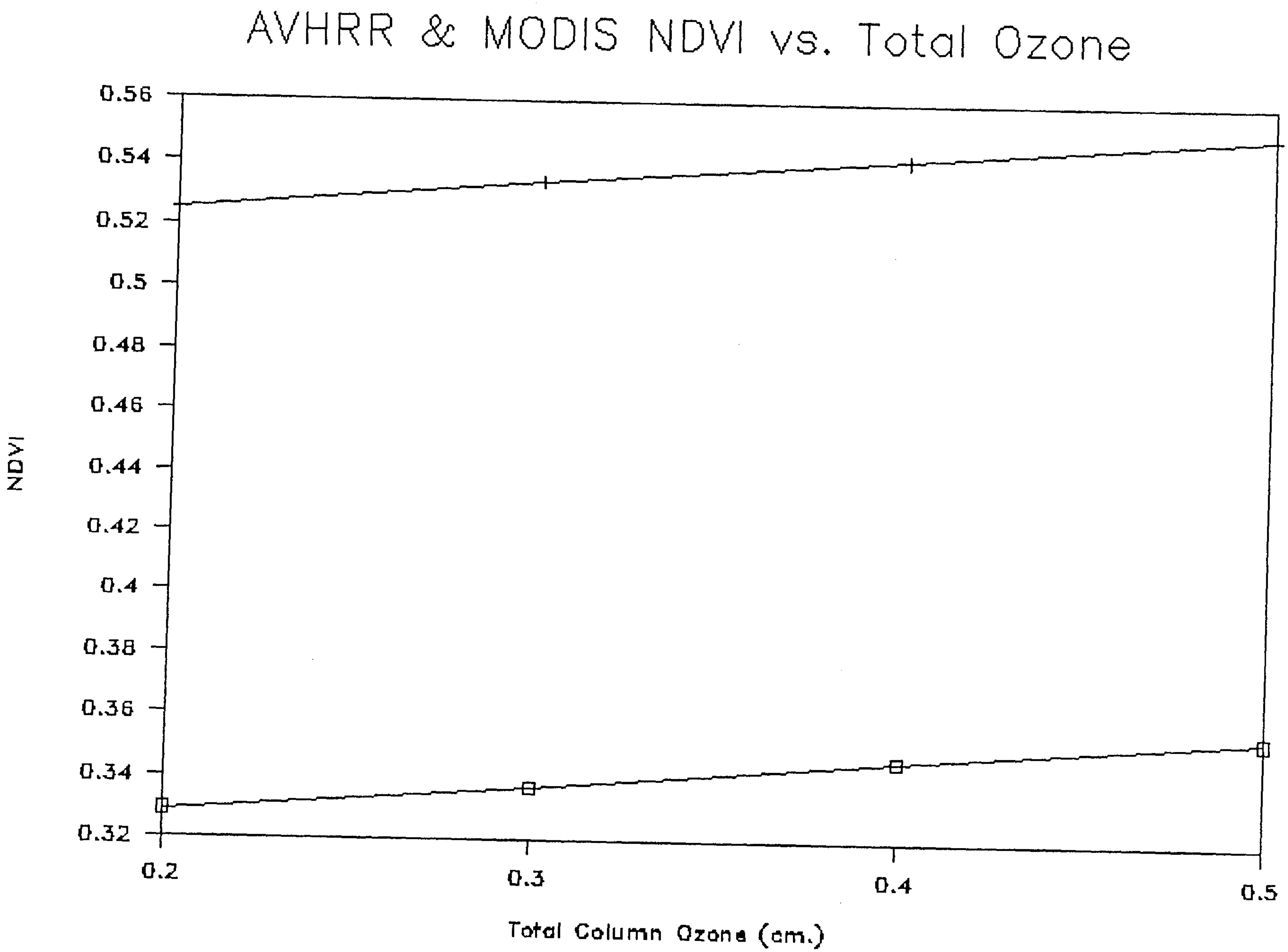


Figure 9.3.1 Spectral albedo of various ground covers. Adapted from Paltridge and Platt [2].



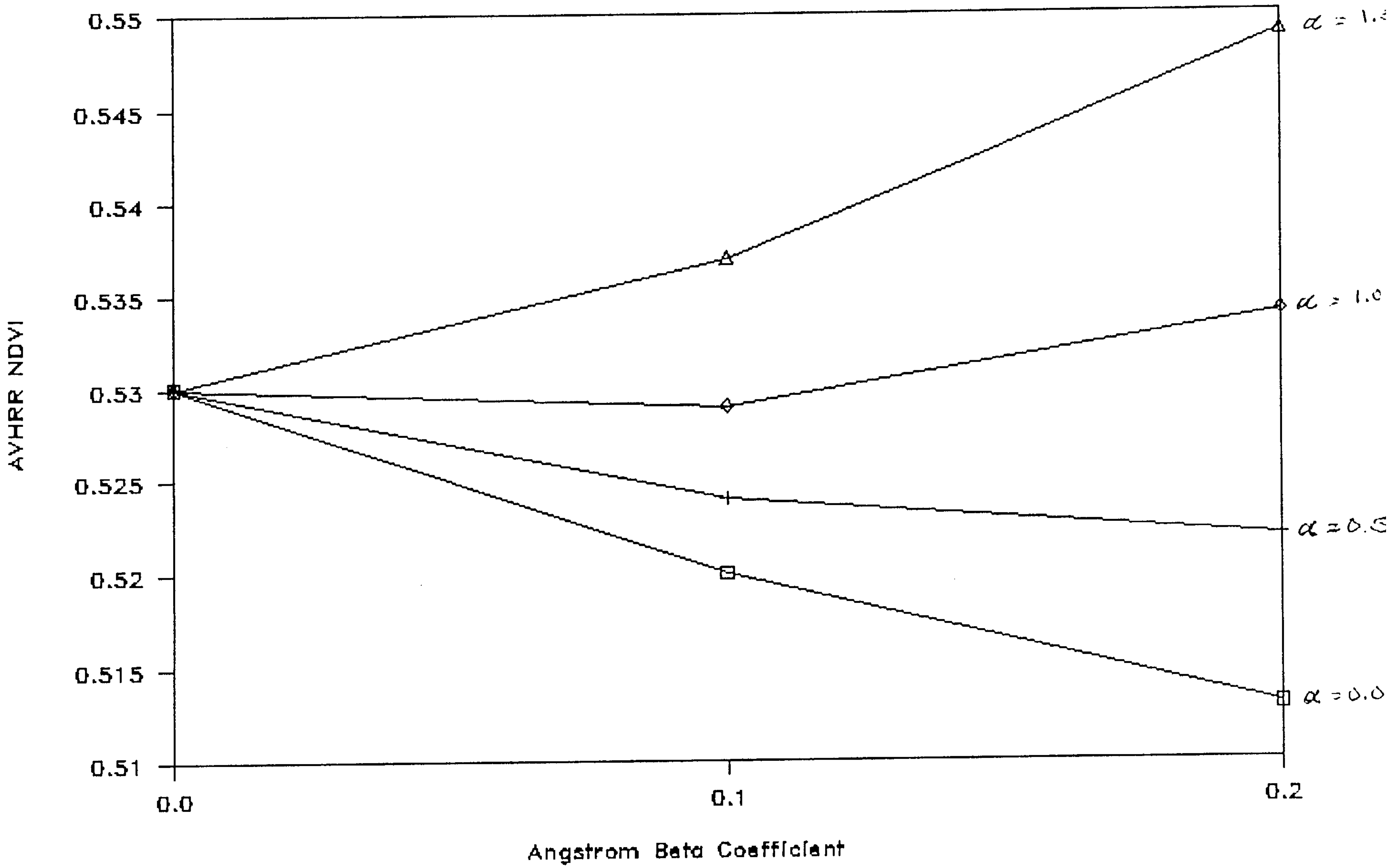
Typical Modis Radiances over Land
with very green vegetation
Radiance (mw/cm**2/sr/um)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.300
0.350
0.450
0.550
0.724
0.832
0.965
1.170
1.477
1.678
2.100
2.900
3.900
Wavelength in microns


Typical Modis Radiances over Land
with dry or brown vegetation
Radiance (mw/cm**2/sr/um)
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
0.300
0.350
0.450
0.550
0.724
0.832
0.965
1.170
1.477
1.678
2.100
2.900
3.900
Wavelength in microns


AVHRR & MODIS NDVI vs. Total Ozone
NDVI
0.56
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
0.38
0.36
0.34
0.32
0.2
0.3
0.4
0.5
Total Column Ozone (cm.)

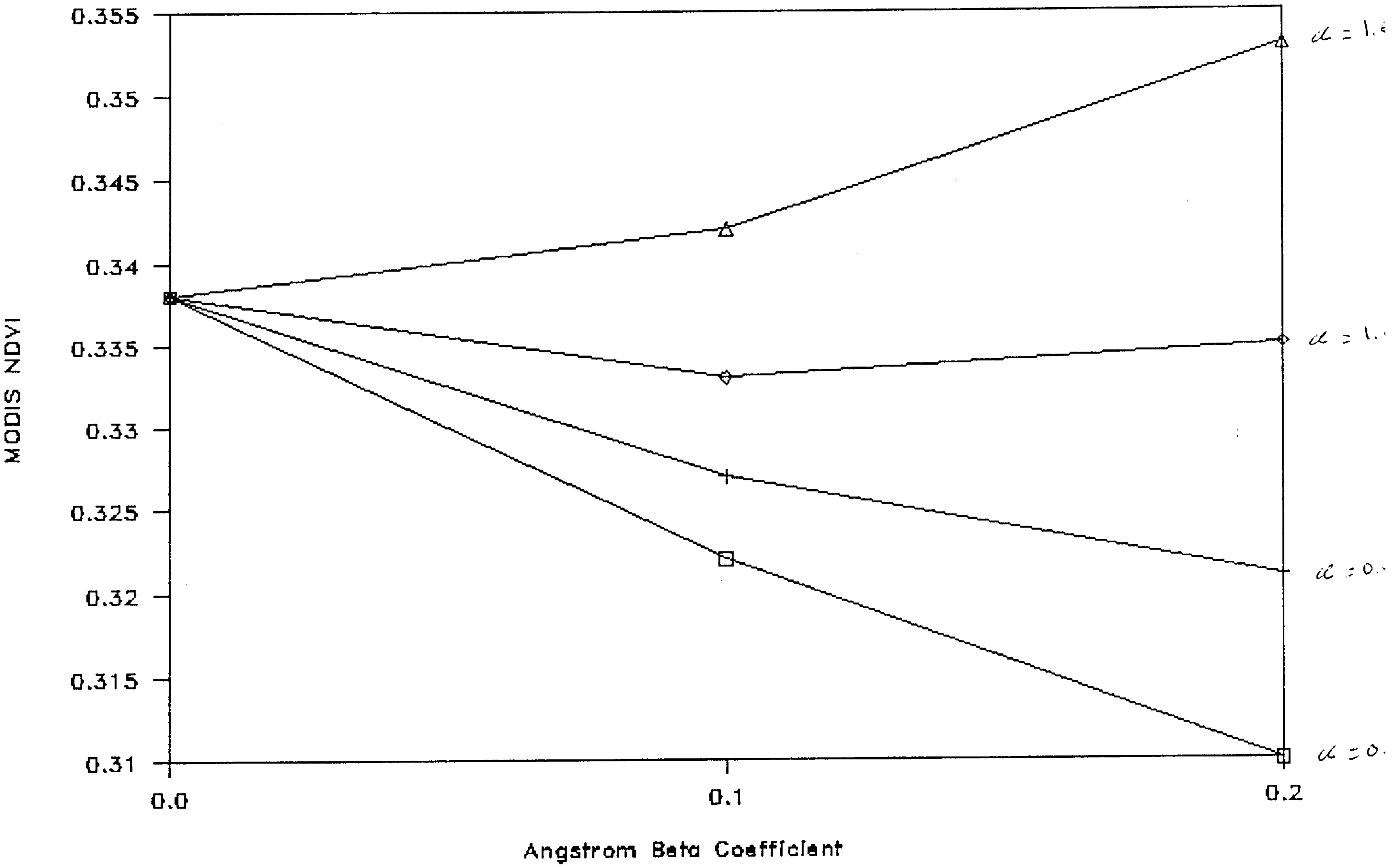
AVHRR NDVI vs. Aerosol Optical Depth

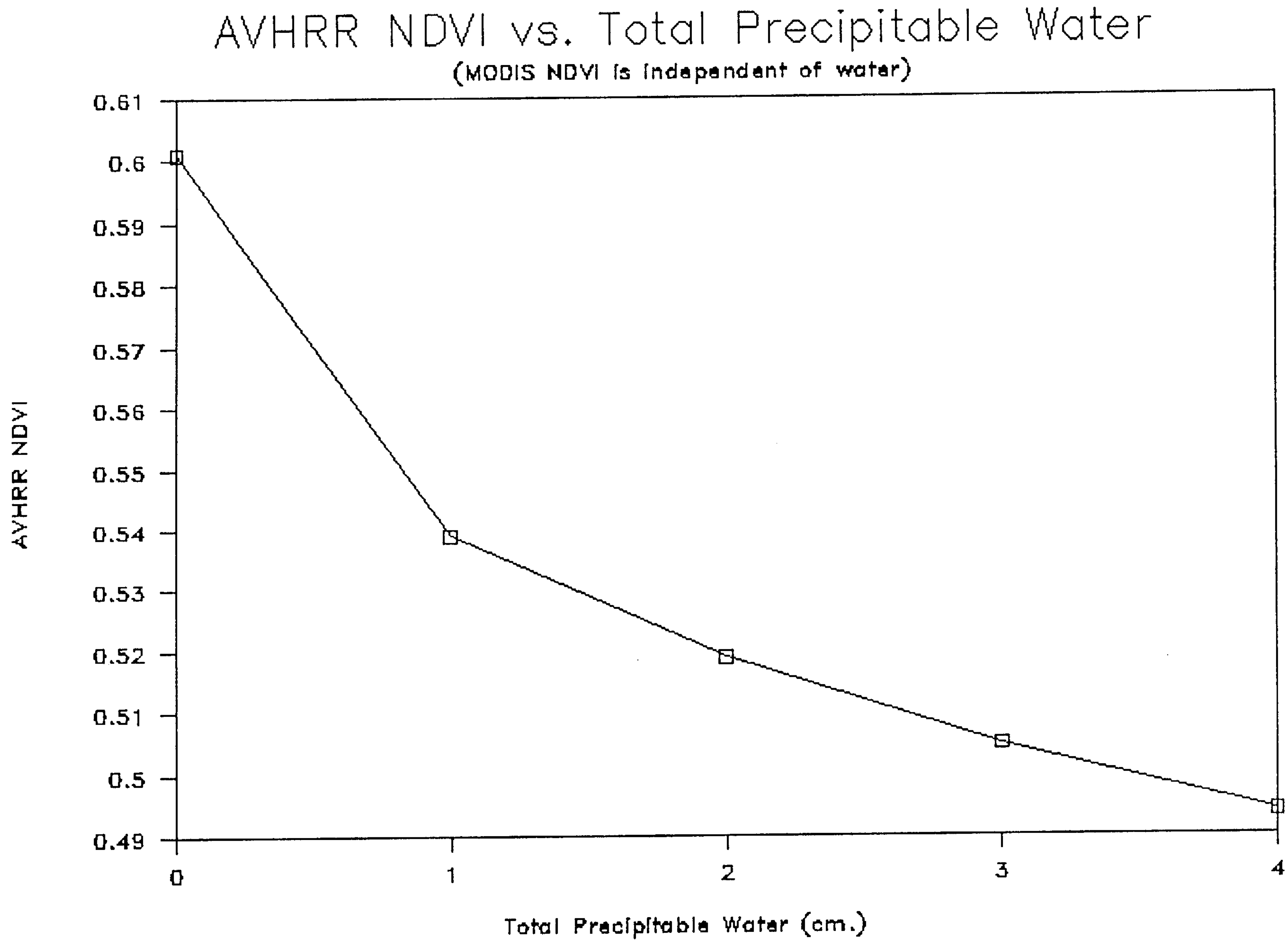
for various aerosol size distributions



MODIS NDVI vs. Aerosol Optical Depth

for various aerosol size distributions




AVHRR NDVI vs. Total Precipitable Water
(MODIS NDVI is independent of water)
AVHRR NDVI
0.61
0.6
0.59
0.58
0.57
0.56
0.55
0.54
0.53
0.52
0.51
0.5
0.49
0
1
2
3
4
Total Precipitable Water (cm.)

"GREENEST" PIXELS FOR AVHRR:

1) Drier air
2) Greater ozone
3) Higher turbidity for continental aerosols or
4) Lower turbidity for oceanic aerosols
5) Large scan angles (small effect up to 40 degrees)

"GREENEST" PIXELS FOR MODIS:

1) Independent of total precipitable water
2) Greater ozone
3) Higher turbidity for continental aerosols or
4) Lower turbidity for oceanic aerosols (MODIS is more sensitive to aerosol effects than AVHRR)
5) Large scan angles (small effect up to 40 degrees, but greater than for AVHRR)

Note: "Greenest" pixel is one with the maximum NDVI out of group of measurements (e.g., weekly set of measurements of one site).

CONCLUSIONS

- Because of different band-passes, the top of the atmosphere NDVI's derived by MODIS and AVHRR will differ substantially in the mean.

- The response to changes in atmospheric composition are different for the two instruments.

- The AVHRR NDVI is a function of total precipitable water whereas the MODIS NDVI is not.

- The two instruments have slightly different responses to the viewing geometry of the scenes.

- The selection of the "greenest" pixel for the two instruments will not necessarily be the same pixel for the two instruments.

- The two NDVI's may be combined into a single time series by:

    - Theoretical studies.

    - Simulation of the AVHRR NDVI by combining several MODIS bands into clusters to match the broad AVHRR bands.

    - Empirical studies (if the two measurements are made simultaneously).